668-5.

with John C Daniell's compliments. The latest results will be found at the end of the enclosed white pamphlet. J C D

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The Holzer-Frith Process for Hardening and Annealing Steel.

THE HOLZER STEEL PROCESS
SYNDICATE (United Kingdom), Ltd.,
24, ROOD LANE, E.C.

668-5.

The Holzer-Frith Process for Hardening and Annealing Steel.

THIS process has the effect of hardening steel without making it brittle, and annealing it without making it softer—both results being obtained at one and the same time by means of a new development in the art of improving steel **after** manufacture, which perhaps is best described by the phrase **"annealing under pressure."**

The theory of hardening as now applied in practice is well known, namely, heating the steel and plunging it while still hot into a cold medium. This plunging causes sudden contraction consequent on an endeavour on the part of the molecules, both of the steel and of the medium into which it is plunged, to obey the natural law and instantaneously establish equilibrium in motion between themselves. This endeavour causes unequal internal pressure throughout the mass, and therefore unequal contraction, which is further intensified by the present means of irregular cooling more fully referred to later.

It is admitted that (without taking into consideration the proportion and condition of the carbon in the steel which naturally affects its hardness) the degree of hardness produced varies with the heat at which, and the manner in which, the steel is plunged ; it also depends upon the properties of the cooling medium and upon the difference in temperature between it and the steel at the time of plunging. This difference in temperature regulates the suddenness of the contraction, *i.e.*, the amount of pressure obtained.

Under the existing methods of cooling in the presence of air (in the case of armour plates and similar manufactures where more care is taken other means are adopted) hardened steel is, generally speaking, very brittle, owing to the unequal or irregular contraction during the time of cooling, which causes great internal strains to be set up. These strains are extremely dangerous, and when the steel has been made **specially hard** by unusually sudden contraction, *i.e.*, **unusually great pressure**, they even at times cause a break before the steel has been used, the extra pressure naturally increasing the force of the internal strains set up by the unequal contraction.

The theory of annealing is equally well known as a means of correcting the irregularities in strength occasioned by the internal strains which arise from unequal contraction during cooling, as instanced above. This operation apparently enables the molecules, after they have been loosened by heat (which should be as uniformly applied as possible), to assume during the time of **slow cooling** a more uniform and normal condition with respect to one another, by slowly forming their natural crystals. This operation lessens the probability of internal strains, the cooling being, as mentioned, slow, and the metal while thus cooling being usually to some extent screened from the air, in order to admit of, as far as possible, regular contraction. A more uniform material is, therefore, no doubt obtained, but inasmuch as material having been expanded by the application of heat cannot, without the assistance of pressure, contract to its original size, steel is consequently softer after being annealed than before. In short, steel has hitherto been **annealed** under **expansion**, as opposed to having been **hardened** under **pressure**.

Under the Holzer-Frith Process the operation of plunging is totally done away with, the material to be treated being placed in a tank, capable of being hermetically sealed, containing mercury at its ordinary temperature, the quantity of mercury naturally depending upon the size of the object to be treated as compared with the dimensions of the tank. After sealing the tank, heat is applied, and the material under treatment is not removed until all is cold.

The necessary **heat** is obtained from Gas or Coke furnaces.

The **mercury** contained in the hermetically sealed tank ensures :—

(*a*) **Hardening**—the natural effect of the pressure arising from the expansion of a hardening medium such as mercury in the tank (which pressure continues to act during cooling).

(*b*) **The total exclusion of the atmosphere.**

(*c*) **Regular cooling** and **therefore equal contraction** throughout the mass (*particularly* as the pressure is acting during the process of cooling).

Further improvements are obtained by the application of an electric current to the material while under treatment.

The use of mercury does not, as might be imagined, entail great expense, as with a properly constructed tank no vapour escapes, and as the tank is always kept screwed down, except when the mercury is cold, there is consequently no liability to waste. With mercury too, as is well known, there is no possibility of explosion.

Without considering the comparatively newly-discovered beneficial effects of the application of an electric current to steel and iron under proper conditions, the **pressure** exerted is of an entirely **novel kind,** acting equally on all sides of the material under treatment at the same time and continuing to act during the time of cooling. The slow cooling under such pressure in the absence of air (which cooling can of course be regulated) is very uniform, and therefore ensures equal contraction throughout the mass so far as it seems possible to obtain it.

Equal contraction represents uniform production, neither of which are obtained by any process previously discovered.

The steel when removed from the tank shows that it has not expanded and that there is no oxidation.

Following on the lines indicated a series of tests has been made during the pasts 2½ years (while patents for all the important countries in the world were being obtained), and the following are a few of the results of tests up to the present date, which prove that the process can be adapted to improve various kinds of steel, and that the steel for whatever purposes it is required (either in an offensive or defensive way) by having been rendered tough and uniform has considerably increased powers :—

Nickel Steel (one of preliminary tests).

2	per cent.	improvement in	breaking strain.
38	,,	,,	elasticity.
50	,,	,,	reduction of area.
9	,,	,,	elongation.

Tool Steel (Bars) (one of preliminary tests).

4 per cent. improvement in breaking strain.
17½ ,, ,, elasticity.
33 ,, ,, elongation.

Tool Steel (Twist drills hardened and tempered). (One of later tests).

4 per cent. improvement in torsional strain.
51 ,, ,, penetrative power.

Mild Steel (Forged Crane Hooks). (One of later tests).
50 per cent. increase in strength.

Non-corrosive Tests (the latest one).

Similar pieces of steel (one treated and one untreated) were immersed in sulphuric acid for 17 days except when exposed to the atmostphere for 15 minutes three times each day. After a further exposure to the atmosphere at the conclusion of the test it was found that the untreated piece was eaten away to the extent of over 75 per cent., whereas the treated piece was not perceptibly corroded, and moreover was barely discoloured.

The following summary emphasizes the great advantages of the Holzer-Frith method of hardening and annealing over the methods at present in use, and shows at a glance that the advantages of the **two** operations now in use are not only all included in the **one** operation of the Holzer-Frith Process, but that by the adoption of this latter process other most important advantages are secured :—

MEANS NOW IN USE.

Operation 1—Hardening.	**Operation 2—Annealing.**
(*a*) Heat.	(*a*) Uniform heat.
(*b*) Sudden chilling (causing sudden contraction or pressure).	(*b*) Partial exclusion of air.
(*c*) Irregular cooling (causing unequal contraction).	(*c*) Slow and fairly regular cooling (causing fairly equal contraction).

RESULTS.

Hard and brittle material.	Fairly uniform material, but softer.

MEANS ADOPTED BY THE HOLZER-FRITH PROCESS.

Sole Operation.

(*a*) Uniform heat.

(*b*) Uniform (mercurial) pressure. Total exclusion of air.

(*c*) Slow and regular cooling (ensuring very equal contraction, as mercurial pressure is also acting during the time of cooling).

(*d*) The application (under certain conditions) of an electric current as an agent for polarizing and effecting other changes.

RESULT.

A hard and tough, or very hard and very tough but not brittle, uniform material, giving the advantage which logically follows of resisting, to a surprising extent, corrosion by salt water and the atmosphere (see test before referred to).

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